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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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Introduction

The present document is part of a TS-family covering the 3rd Generation Partnership Project Technical Specification Group Services and System Aspects, Telecommunication management; as identified below:

TS 32.551: Energy Savings Management (ESM); Concepts and Requirements

Stage 2 for Energy Savings Management is contained in:

TS 32.522 [5]: Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)

TS 32.762 [4]: Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)

TS 32.642 [7]: Configuration Management(CM); UTRAN network resources Integration Reference Point (IRP): Network Resource Model (NRM)

TS 32.652 [8]: Configuration Management(CM); GERAN network resources Integration Reference Point (IRP): Network Resource Model (NRM)

This work is based on the Study contained in TR 32.826 [2] Study on Energy Savings Management (ESM) and TR 32.834 [9] Study on Operations, Administration and Maintenance (OAM) aspects of inter-Radio-Access-Technology (RAT) energy saving.

1 Scope

The present document describes the concepts and requirements how energy savings functionalities are managed what requirements need to be met to support this. The document also describes if a requirement shall be met via the Itf-N interface or via other means.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 32.826: "Telecommunication management; Study on Energy Savings Management (ESM)".

[3] 3GPP TS 25.104: "Base Station (BS) radio transmission and reception (FDD)".

[4] 3GPP TS 32.762: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[5] 3GPP TS 32.522: "Telecommunication management; Self-Organizing Networks (SON) Policy Network Resource Model (NRM) Integration Reference Point (IRP): Information Service (IS)".

[6] 3GPP TS 32.500: "Telecommunication management; Self-Organizing Networks (SON); Concepts and requirements".

[7] 3GPP TS 32.642: "Configuration Management(CM); UTRAN network resources Integration Reference Point (IRP): Network Resource Model (NRM)".

[8] 3GPP TS 32.652: "Configuration Management(CM); GERAN network resources Integration Reference Point (IRP): Network Resource Model (NRM)".

[9] 3GPP TR 32.834: "Study on Operations, Administration and Maintenance (OAM) aspects of inter-Radio-Access-Technology (RAT) energy saving ".

[10] 3GPP TS 36.300: " E- UTRA and E-UTRAN; Overall description; Stage 2".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Centralized ES: ES solution where ES algorithms are executed in the OAM system. Centralized ES has two variants:

- **NM-Centralized ES:** ES solution where ES algorithms are executed at the Network Management level.
- **EM-Centralized ES:** ES solution where ES algorithms are executed at the Element Management level.

Distributed ES: ES solution where ES algorithms are executed at the Network Element level.

notEnergySaving state: the default state in peak-traffic situation, with no specific energy saving in progress.

energySaving state: in an off-peak-traffic situation, some functions of a cell or a network element are powered-off or restricted in resource usage in other ways, whereas the cell or network element is still controllable.

ES Probing procedure : Upon being triggered by the Cell Activation Request message - of the Cell Activation procedure (see TS 36.300 [10] section 20.2.2.15) - sent from a node owning a candidate cell, eNBs owning ES probing capable original cell(s) indicate its (their) presence to UEs for a period of time which last up to the Minimum Activation Time (see TS 36.300 [10] section 22.4.4.2) . An ES probing cell prevents idle mode UEs from camping on the cell and prevents incoming handovers to the same cell. The results of these measurements are used to determine whether the cell has UEs within its reach and thus could take over load by going into the notEnergySaving state.

compensatingForEnergySaving state: in an off-peak traffic situation, a network element is remaining powered on, e.g. taking over the coverage areas of neighbor base station in energySaving state.

ES activation: the procedure to switch off a cell or network element or restrict the usage of physical resources for energy saving purposes. As a result, a specific network element transitions is in energySaving state.

ES compensation: the procedure to change a cell"s or network element"s configuration to remain powered on for compensating energy saving activation on other cells or network elements, e.g. by increasing a base station"s coverage area. As a result, the network element is in compensatingForEnergySaving state.

ES deactivation: the procedure to switch on a cell ornetwork element or resume the usage of physical resources which had been ES activated before. As a result, a specific network element is in notEnergySaving state.

Enable ES: ES (including ES activation/compensation/deactivation, related computations etc.) is allowed to be performed.

Disable ES: ES is prohibited to be performed. When ES is disabled, subject cells or NEs are in notEnergySaving state.

Candidate cell: candidate cell is a cell which can provide coverage when the original cell goes into energySaving state.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ES	Energy Saving
ESM	Energy Saving Management

4 Concepts and Backgrounds

4.1.0 Introduction

Protecting the environment and combating climate change are challenges that we face today. In the telecom environment, as energy prices increase, there is added incentive for Network Operators to look for means to reduce energy costs.

OAM of mobile networks can contribute to energy saving by allowing the operator to set policies to minimize consumption of energy, while maintaining coverage, capacity and quality of service. The permitted impact on coverage, capacity and quality of service is determined by operator"s policy.

When a cell is in energy savings state it may need neighbouring cells to pick up the load. However a cell in energySaving state cannot cause coverage holes or create undue load on the surrounding cells. All traffic on that cell is expected to be drained to other overlaid/umbrella cells before any cells moves to energySaving state.

A cell in energySaving state is not considered a cell outage or a fault condition. No alarms should be raised to the IRPManager for any condition that is a consequence of a NE moving into energySaving state

In addition, the use of the renewable energy sources (e.g. wind, solar energy) should be encouraged in mobile networks.

The following ESM concepts can apply to different RATs, e.g. UMTS and LTE. Nevertheless some of these ESM concepts may be limited to specific RATs and network elements, and specific solutions may be required for them.

4.1.1 Fundamental concepts

Two energy saving states can be conceptually identified for a cell or a network element:

Conceptually, a cell or a network element may be on one of these two states with respect to energy saving:

- notEnergySaving state
- energySaving state

Based on the above energy saving states, a full energy saving solution includes two elementary procedures:

- Energy saving activation (change from notEnergySaving to energySaving state)
- Energy saving deactivation (change from energySaving to notEnergySaving state)

In nonN M-centralized solution optionally the ES probing procedure maytake place.

Table : Criteria for energy saving state

Criterion	notEnergySaving state	energySaving state
Degree of energy saving effect	The cell in notEnergySaving state will not consider energy saving as the first priority, but it is left to the vendor implementation how to minimize energy consumption while providing service availability. This minimization may include switching off hardware elements.	The energySaving state represents the maximum energy saving effect on the cell level. Hardware components shall be switched off for energy saving purpose as far as possible.Which hardware components are switched off is an issue specific to NE implementation. During an ES probing procedure, the radio transmitter needs to be active up to the Minimum Activation Time as defined in TS 36. 300[10]
Controllability from the network	The notEnergySaving state has no direct impact on controllability. I.e. in normal circumstances the cell in notEnergySaving state is under control of the network and the network interfaces as X2/S1 and OAM connection are enabled when the cell is in notEnergySaving state.	The energySaving state has no direct impact on controllability. I.e. in normal circumstances the cell in energySaving shall support the capability to be switched on again by the network, such as by its neighboring cells (eNBs) or the OAM system and a network interface such as X2/S1 or the OAM connection is enabled when the cell is in energySaving state. ES probing procedure has no impact on controllability.
Service availability	The cell in notEnergySaving state should provide complete service to UEs in the coverage area of a cell. From the view of such an UE, the cell in notEnergySaving state is visible when the UE scans all RF channels according to its capabilities.	The cell in energySaving state does not provide any service to UEs. From the view of an UE, a cell in energySaving state is normally not visible. During an ES probing procedure, the cell in energySaving state is visible and may be measured up to the Minimum Activation Time as defined in TS 36. 300[10]. , however the cell does not provide any service to UEs.

4.1.2 Additional concepts for selected uses cases

For selected ESM use cases, a network element may additionally transition to the

- compensatingForEnergySaving.

Correspondingly, such use cases may provide these additional procedures:

- Energy saving compensation activation.
- Energy saving compensation deactivation: the procedure to decrease a previously increased coverage area.

This compensation concept, i.e. the energy saving state compensatingForEnergySaving and the additional procedures for energy saving compensation (de)activation, does not apply to Inter-RAT Energy Saving concepts.

4.1.3 Operator control

Three general architectures are candidates to offer energy savings functionalities:

Distributed, NM-Centralized, EM-Centralized as defined in TS 32.500 [6].

Energy savings in cells can be initiated in several different ways. Some of the mechanisms are:

For NM-centralized architecture

- IRPManager instructs the cells to move to energySaving state (e.g. according to a schedule determined by network statistics) , configures trigger points (e.g. load threshold crossing) when it wants to be notified, deactivates the energy saving of a network element.

For EM-centralized and distributed architecture

- IRPManager sets policies and conditions and when these policies/conditions are met, the cells will move to energy saving state.
  Examples for policies/conditions are: A time period, during which energy saving is allowed; definition of cells

which are to be considered when a ES decision is made; load thresholds to be considered for energy saving decisions to determine from when on energy saving shall be done and which of the RATs should be 'ramped down' first, which second etc.

- Based on these policies/conditions and further information – e.g. the operational status of the candidate cell to take over - the ESM function controls the energy saving measures in the network elements. The network operator is informed about configuration changes which are triggered by the ESM function.
  In the case of distributed architecture the eNB moves itself to/from energySaving state autonomously

5 Business level requirements

5.1 Requirements

REQ-32.551-CON-01

The acceptable impact on services shall be determined based on operator"s policy.

REQ-32.551-CON-02

The IRPManager shall be able to monitor how the network and the user service quality are influenced by energy saving function.

REQ-32.551-CON-03

IRPManager shall be able to monitor the performance of the energy saving function.

REQ-32.551-CON-04

The IRPAgent shall support a capability allowing the IRPManager to retrieve energy consumption information for each of its managed NEs.

REQ-32.551-CON-05

The IRPAgent should support a capability allowing the IRPManager to configure for each of its managed NEs the period of time for which energy consumption information will be provided.

REQ-32.551-CON-06

The IRPManager shall be able to initiate energy saving compensation activation and/or deactivation on one or multiple cells or network elements.

This requirement applies for the use case capacity limited network, for other use cases it is FFS.

REQ-32.551-CON-07

IRPManager shall be able to enable and disable energy saving for a selected part of the network.

REQ-32.551-CON-08

The IRPAgent shall support a capability allowing the IRPManager to initiate energy saving activation/deactivation on one or multiple cells or network elements in the network.

REQ-32.551-CON-09

When a NE is in energySaving state the IRPAgents shall not consider the NE as a fault, and no alarms shall be raised to the IRPManager for any condition that is a consequence of an energySaving NE.

REQ-32.551-CON-10

The IRP Agent shall be able to allow the IRPManager to define a list of cells to prevent them from going into energySaving state.

REQ-32.551-CON-11

The IRPAgent shall allow the IRPManager to query which cells in the network under its domain are in the energySaving state.

REQ-32.551-CON-12

The IRPAgent shall support a capability to notify the IRPManager when a cell goes into or out of energySaving state.

REQ-32.551-CON-13

The IRPAgent shall notify the IRPManager when a cell fails to re-start as a result of going out of energySaving state.

REQ-32.551-CON-14

The IRPAgent should support a capability allowing the IRPManager to configure a cell traffic load threshold to be used for the decision if a network element goes into energySaving state.

REQ-32.551-CON-15

The IRPAgent should support a capability allowing the IRPManager to configure a cell traffic load threshold to be used for the decision if a network element goes out of energySaving state.

REQ-32.551-CON-16

The system shall bring cells within one node into energySaving state in the most energy efficient sequence.

REQ-32.551-CON-17

A cell must not go into energySaving state until emergency calls or Wireless Priority Service calls in the cell are completed. Forcing handovers of such calls because of ES shall be avoided.

REQ-32.551-CON-18

The IRPManager shall be able to access location and coverage information for each of its managed NEs.

REQ-32.551-CON-19

The IRPAgent shall provide the capability to allow the IRPManager to configure one or more related cells as the candidate cells to take over the coverage when the original cell is going into energySaving state.

This requirement applies to the cell overlaid use case.

REQ-32.551-CON-20

The IRPAgent shall provide a capability to allow the IRPManager to indicate cell outage of an overlay cell that is a candidate cell that can take over the coverage for another cell.

This requirement applies to the cell overlaid use case.

REQ-32.551-CON-21

A cell or a network element in energySaving state is a planned condition and should not be considered as an outage.

REQ-32.551-CON -22

Energy Saving shall not prevent the fulfillment of emergency service requirements (e.g. E911) and Wireless Priority Services requirements.

REQ-32.551-CON -23

The IRPAgent should provide a capability to allow the IRPManager to query which cells support the ES probing procedure.

5.2 Actor roles

TBD

5.3 Telecommunication resources

TBD

5.4 High level use cases

5.4.1 Cell overlaid use case

In this use case an eNB can only enter into an energy saving state if there is radio coverage by other radio systems – be it another eNB or an entity of another radio access technology - for the whole coverage area of the eNB in question.

This use case applies both for Intra- and Inter-RAT Energy Saving.

5.4.2 Capacity limited network use case

In this use case the coverage area of a group of eNBs is taken care of by one or more of its eNBs while the others go into energy saving state

This use case applies for Intra-RAT Energy Saving and does not apply for Inter-RAT Energy Saving..

6 Specification level requirements

6.1 Requirements

6.1.1 Common requirements

REQ-ComES-FUN-01

The IRPManager shall be able to monitor how the network and the user service quality are influenced by energy saving function.

REQ-ComES-FUN-02

IRPManager shall be able to monitor the performance of the energy saving function.

REQ-ComES-FUN-03

The IRPAgent shall support a capability allowing the IRPManager to retrieve energy consumption information for each of its managed NEs.

REQ-ComES-FUN-04

The IRPAgent should support a capability allowing the IRPManager to configure for each of its managed NEs the period of time for which energy consumption information will be provided.

REQ-ComES-FUN-05

When a NE is in energySaving state the IRPAgents shall not consider the NE as a fault, and no alarms shall be raised to the IRPManager for any condition that is a consequence of an energySaving NE.

REQ-ComES-FUN-06

void

REQ-ComES-FUN-09

The IRPAgent shall allow the IRPManager to query which cells in the network are in energySaving state.

REQ-ComES-FUN-07

The IRPAgent shall support a capability to notify the IRPManager when a cell goes into or out of energySaving state.

REQ-ComES-FUN-08

The IRPAgent shall notify the IRPManager when a cell fails to re-start as a result of going out of energySaving state.

REQ-ComES-FUN-09

The IRPAgent should provide a capability to allow the IRPManager to query which cells support the ES probing procedure.

6.1.2 Requirements for NM Centralized ES

REQ-NCES-FUN-01

The IRPAgent shall support a capability allowing the IRPManager to initiate energy saving compensation activation to one or multiple cells or network elements.

This requirement applies for the use case capacity limited network.

REQ-NCES-FUN-05

The IRPAgent shall support a capability allowing the IRPManager to initiate energy saving compensation deactivation to one or multiple cells or network elements.

This requirement applies for the use case capacity limited network.

Editor"s note: this requirement is here presented not in sequential order for readability purpose.

REQ-NCES-FUN-02

The IRPAgent shall support a capability allowing the IRPManager to initiate energy saving activation to one or multiple cells or network elements.

REQ-NCES-FUN-03

The IRPAgent shall support a capability allowing the IRPManager to initiate energy saving deactivation to one or multiple cells or network elements.

REQ-NCES-FUN-04

The IRPAgent shall provide a capability allowing the IRPManager to monitor the network load.

6.1.3 Requirements for EM Centralized ES

See all requirements for Distributed ES.

6.1.4 Requirements for Distributed ES

REQ-DIES-FUN-01

The IRP Agent shall be able to allow the IRPManager to define a list of cells to prevent them from going into energySaving state.

REQ-DIES-FUN-02

The IRPAgent shall provide the IRPManager the possibility to define that a cell is prohibited to be reconfigured for Energy Saving purposes.

This requirement applies for the capacity limited use case.

REQ-DIES-FUN-03

The IRPAgent should support a capability allowing the IRPManager to define a traffic threshold and a time duration: If the traffic in the active neighbor cells is above this threshold longer than this time duration, then the cell can leave the energySaving state.

REQ-DIES-FUN-04

The IRPAgent shall provide the capability to allow the IRPManager to configure one or more related cells as the candidate cells to take over the coverage when the original cell is going into energySaving state.

This requirement applies for the cell overlaid use case.

REQ-DIES-FUN-05

The IRPAgent shall provide a capability to allow the IRPManager to indicate cell outage of an overlay cell that is a candidate cell that can take over the coverage for another cell.

This requirement applies for the use case cell overlaid.

REQ-DIES-FUN-06

The IRPAgent should support a capability allowing the IRPManager to define a traffic threshold (threshold1) for the cell, a traffic threshold (threshold2) for the neighbour cells and a time duration; if the traffic in the cell is below this threshold1 longer than this time duration and the traffic in active neighbor cells is below this threshold2 longer than this time duration, then the cell can enter the energySaving state.

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REQ-DIES-FUN-07

Void.

REQ-DIES-FUN-08

The IRPAgent should support a capability allowing the IRPManager to define in a uniform way on subnetwork level or for many cells the circumstances when entering or leaving the energy saving is allowed.

REQ-DIES-FUN-09

The IRPManager shall be able to switch on (= enable) and switch off (= disable) energy saving for a selected part of the network. Switch off energy saving by the IRPManager shall be possible at any time, even if the selected NEs are in energySaving state.

REQ-DIES-FUN-10

The IRPAgent should support a capability allowing the IRPManager to configure the time period during which energy saving is allowed.

REQ-DIES-FUN-11

If the IRPAgent has no direct access to outage information about candidate cells, then the IRPManager should be able to indicate cell outage of such a cell.

REQ-DIES-FUN-12

The IRPAgent should support a capability allowing IRPManager to indicate that the outage of a candidate cell shall end and prohibit the energy saving activiation of specific cells.

6.2 Actor roles

TBD

6.3 Telecommunication resources

TBD

6.4 High level use cases

6.4.0 General

All parts of the descriptions in clause 6.4 which mention compensation for energy saving do not apply for Inter-RAT Energy Saving. Apart from that, these use cases apply both for inter- and intra-RAT energy saving.

6.4.1 Energy saving activation on selected network elements (Centralized ES on NM layer)

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	Activating energy saving for a selected network elements in a part of the network	
Actors and Roles (*)	IRPManager as user	
Telecom resources	Network elements (NEs) and their OSS.	
Assumptions	Centralized ES on NM layer is performed. The network operator has decided to activate energy saving on selected network elements in a part of the network (network elements, e.g. base stations). This requires to activate energy saving on some network elements and to activate compensatingForEnergySaving on others. IRPManager is continuously monitoring load on NEs. An interference control function is available to support the coverage adjustment process among NEs in ES-Compensate and energySaving state.	
Pre conditions	The network topology should allow transferring some network elements into energySaving state while maintaining coverage by transferring some other into ES-Compensate state. Network elements (e.g. base stations) are not in a faulty state.	
Begins when	The IRPManager decides to activate energy saving on selected network elements in a part of the network based on monitored decreased network load.	
Step 1 (*) (M)	The IPRManager makes a decision on which NEs should enter energySaving state, compensatingForEnergySaving state, or notEnergySaving state based on network load, geographic positions and maximum coverage of base stations.	
Step 2 (*) (M)	Based on the output of step1, the IRPManager initiates energy saving activation and energy saving compensation activation on the NEs selected for the respective state transition. The energy saving compensation activation is achieved by reconfiguration of coverage related parameters over Itf-N. Such coverage related parameters are parameters to be optimized in use case Capacity and Coverage Optimization (See 32.522).	
Step 3 (*) (M)	After the completion of the energy saving activation process, the IRPAgent informs the IRPManager on the result of the process.	
Ends when (*)	The selected network elements are in energySaving state, and other selected network elements are in compensatingForEnergySaving state.	
Exceptions	FFS	
Post Conditions	Energy saving activation has been performed on some selected NEs. Other selected NEs are in compensatingForEnergySaving state. The network coverage is maintained. The network capacity is adapted to the reduced load.	
Traceability (*)	REQ-NCES-FUN-01**,** REQ-NCES-FUN-02, REQ-NCES-FUN-04	

6.4.2 Deactivation of energy saving on selected network elements (Centralized ES on NM layer)

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	Deactivating energy saving for a selected part of the network	
Actors and Roles (*)	IRPManager as user	
Telecom resources	Network elements (NEs) and their OSS.	
Assumptions	Centralized ES on NM layer is performed. The network operator has decided to activate energy saving on selected network elements in a part of the network (network elements, e.g. base stations). This requires to activate energy saving on some network elements and to activate energy saving compensation on others. The IRPManager is continuously monitoring load on NEs. An interference control function is available to support the coverage adjustment process among NEs in compensatingForEnergySaving and energySavingstate.	
Pre conditions	The affected network elements are in energySavingstate or in ES-Compensate state. Network elements (base stations) are not in a faulty state.	
Begins when	The IRPManager decides to deactivate energySaving for selected network elements in a part of the network based on network load.	
Step 1 (*) (M)	The IPRManager makes a decision on which NEs should remain in energySaving state or compensatingforEnergySaving state, or enter notEnergySaving state based on network load, geographic positions and maximum coverage of base stations.	
Step 2 (*) (M)	Based on the output of step1, the IRPManager initiates energy saving deactivation and energy saving compensation deactivation on the NEs selected for the respective state transition. The energy saving compensation deactivation is achieved by reconfiguration of coverage related parameters over Itf-N. Such coverage related parameters are parameters to be optimized in use case Capacity and Coverage Optimization (See 32.522).	
Step 3 (*) (M)	After the completion of the energy saving deactivation process, the IRPAgent informs the IRPManager on the result of the process.	
Ends when (*)	The selected network elements are in No-ES state.	
Exceptions	FFS.	
Post Conditions	Energy saving deactivation has been performed on the selected NEs. The selected NEs are in notEnergySaving state. The network coverage is maintained. The network capacity accommodates the increased load.	
Traceability (*)	REQ-NCES-FUN-01**,** REQ-NCES-FUN-03, REQ-NCES-FUN-04	

6.4.3 Energy saving activation on selected network elements (Distributed ES)

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	Activating energy saving for a selected network elements in a part of the network	
Actors and Roles (*)	IRPManager as user	
Telecom resources	Network elements (NEs) and their OSS.	
Assumptions	The network operator has enabled the distributed energy saving function on selected network elements in a part of the network (network elements, e.g. base stations). This allows to activate energy saving on some network elements and to activate energy saving compensation on others. An interference control function is available to support the coverage adjustment process among NEs in compensatingForEnergySaving and energySaving state.	
Pre conditions	The network topology should allow transferring some network elements into energySavingstate while maintaining coverage by transferring some others into ES-Compensate state. Network elements (e.g. base stations) are not in a faulty state.	
Begins when	The distributed algorithm decides to activate energy saving on selected network elements in a part of the network based on monitored decreased network load.	
Step 1 (*) (M)	The NE executes the energy saving algorithm to determine which neighboring NEs should enter energySaving, compensatingForEnergySaving, or notEnergySaving state.	
Step 2 (*) (M)	Based on the output of step 1, those NEs that have been selected to be transferred to compensatingForEnergySaving state, initiate energy saving compensation and inform the IRPManager.	
Step 3 (*) (M)	Based on the output of step 1, those NEs that have been selected to be transferred to energySaving state, perform energy saving activation and inform the IRPManager.	
Ends when (*)	The selected base stations are in energySaving state, and other selected base stations are in compensatingForEnergySaving state.	
Exceptions	FFS.	
Post Conditions	Energy saving activation has been performed on some selected NEs. Other selected NEs are in compensatingForEnergySaving state. The network coverage is maintained. The network capacity is adapted to the reduced load.	
Traceability (*)	FFS	

6.4.4 Energy saving deactivation on selected network elements (Distributed ES)

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	Deactivating energy saving for a selected part of the network	
Actors and Roles (*)	IRPManager as user	
Telecom resources	Network elements (NEs) and their OSS.	
Assumptions	The network operator has enabled the energy saving distributed function on selected network elements in a part of the network, so that the NEs can deactivate energy saving state depending on load conditions. An interference control function is available to support the coverage adjustment process among NEs in compensatingForEnergySaving and energySaving state.	
Pre conditions	The affected network elements are in energySaving state or in compensatingForEnergySaving state. Network elements (e.g. base stations) are not in a faulty state.	
Begins when	The distributed algorithm decides to deactivate energy saving for a selected part of the network based on network load.	
Step 1 (*) (M)	The NE executes the energy saving algorithm that decides which NEs remain in energySaving state or compensatingforEnergySaving state or enter notEnergySaving state.	
Step 2 (*) (M)	Based on the output of step 1, those NEs that in energySaving state or compensatingforEnergySaving state which have been selected to be transferred to notEnergySaving state, initiate energy saving deactivation or energy saving compensation deactivation and inform the IRPManager.	
Ends when (*)	The selected network elements are in No-ES state.	
Exceptions	FFS.	
Post Conditions	Energy saving deactivation has been performed on the selected NEs. The selected NEs are in notEnergySaving state. The network coverage is maintained. The network capacity accommodates the increased load.	
Traceability (*)	FFS	

6.4.5 Coordination between Energy Saving and Cell outage

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	The NE energy saving function and cell outage handling function are well coordinated.	
Actors and Roles (*)	IRPManager as user	
Telecom resources	The E-UTRAN network including its OSS.	
Assumptions	1. The operator has configured energy saving policies for the network elements.	
Pre conditions	The network is properly installed and running.	
Begins when		
Step 1 (*) (M)	IRPManager got information about a cell outage.	
Step 2 (*) (M)	IRPManager sends the outage indications to the IRPAgents of related network elements.	
Step 3 (*) (M)	If the related network elements are in energy saving state and the cell in outage was the last or only one to provide overlay coverage for these NEs, they perform energy saving deactivation. The related network elements shall not re-activate energy saving before the cell outage is recovered or another NE provides overlay coverage. The related network elements will take over some or all the coverage of the cell that is in outage state.	
Step 3 (*) (M)	IRPManager sends indication to the related network elements in case the cell outage has been restored. The related network elements can activate energy saving state according to their energy saving policy.	
Ends when (*)	Ends when all steps identified above are completed or when an exception occurs.	
Exceptions	One of the steps identified above fails and retry is unsuccessful.	
Post Conditions	No cell outage exist, ES can act undisturbed	
Traceability (*)	FFS	

6.4.6 Energy saving switch off by IRP Manager on selected network elements (Distributed ES)

Use Case Stage	Evolution / Specification	<<Uses>> Related use
Goal (*)	Switch off distributed energy saving function for a selected part of the network, by IRPManager	
Actors and Roles (*)	IRPManager as user	
Telecom resources	Network elements (NEs) and their OSS.	
Assumptions	The network operator has switched on the distributed energy saving function on selected network elements (sub-network / group of base stations).	
Pre conditions	In the concerned sub-network / group of base stations, some network elements are in energySaving state or in compensatingForEnergySaving state, due to the distributed energy saving function. Network elements (e.g. base stations) are not in a faulty state.	
Begins when	The IRPManager decides to switch off energy the distributed energy saving function for a selected part of the network (sub-network / group of base stations).	
Step 1 (*) (M)	Upon IRPManager"s request, the distributed energy saving function is switched off on the whole selected sub-network / group of base stations.	
Step 2 (*) (M)	Inside the selected sub-network / group of base stations, network elements which were in energySaving state or in compensatingForEnergySaving state are transferred to notEnergySaving state. In the selected sub-network / group of base stations, NEs that were in energySaving state (respectively compensatingforEnergySaving state) are transferred to notEnergySaving state, by initiating energy saving deactivation (resp. energy saving compensation deactivation).	
Step 3 (*) (M)	Based on the output of step 12, those NEsthe IRPAgent informs the IRPManager.	
Ends when (*)	The distributed energy saving function is switched off on selected sub-network / group of base stations and network elements which were in energySaving state or in compensatingForEnergySaving state are in notEnergySaving state.	
Exceptions	FFS.	
Post Conditions	Energy saving switch off has been performed on the selected NEs. The selected NEs are in notEnergySaving state. The network coverage is maintained. The network capacity accommodates the load.	
Traceability (*)	REQ-DIES-FUN-09FFS	

Annex A (informative):
Use case details: Capacity-limited network use case

Capacity-limited networks (e.g. UMTS networks in an urban environment) are normally dimensioned to cope with peak time traffic demand and can hence be under-utilized in off-peak times, e.g. at certain hours of the night, when the overall load as well as the load distribution onto the different cells may differ significantly from peak times.

For energy saving management in such networks, the objective is therefore to adapt the network to these changing conditions by activating energy saving on selected cells. One approach is to concentrate the load into a few selected cells that remain active during low traffic demand periods with increased coverage area and to deactivate the remaining less loaded cells.

This use case is generally RAT-independent, but may provide specific requirements and leverage specific mechanisms of individual RATs. This use case is only applicable to macro base stations.

Overview

In this use case the coverage area of a cell can be configured dynamically, where an operator would employ smaller coverage areas per cell (to increase capacity per geographic area) in a peak traffic situation. In that case some base stations would be enabled to adjust their transmission power and other configuration parameters for their cells at off-peak times in order to provide coverage for other neighboring cells – which could then be transferred to energy saving state, after handing currently associated UEs over to remaining neighboring cells. Activating energy saving on certain base stations and modifying radio parameters for increasing coverage for other cells can lead to different neighbor relations as well as different cell and frequency layouts, which should be addressed by automatic neighbor relation, interference control, e.g. through OAM-driven configuration or SON functions, depending on the specific RAT in use. Depending on the specific scenarios, activating energy saving on base stations could ultimately lead to switching off all radio-transmission-related functions at a site, which would lead to reduced energy consumption and could implicitly lead to even further energy saving, e.g. when air condition systems at a site adapt to the reduced cooling requirements – which is not considered here in detail.

The energy saving management in the scenario would ideally lead to situation for an off-peak time as depicted in figure A.1 – where one base station would remain powered one (depicted as ES-Compensate), taking over the coverage areas of neighbor base stations in energySaving state (depicted as eSaving).

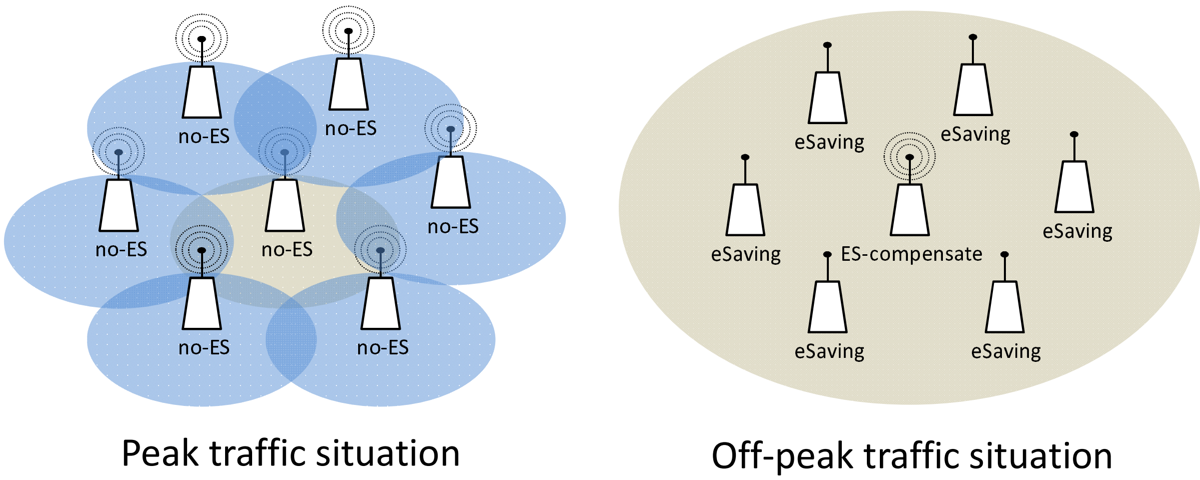

Figure A.1: Different network arrangements corresponding to capacity demand variation for energy saving purposes

As depicted in figure A.1, a certain part of a network, e.g. base stations in a geographical area, can be in two different situations:

1. Peak traffic situation: no particular energy saving is on-going, and network elements are in No-ES state.

2. Off-peak Traffic situation: energy saving is on-going, and some network elements may be in energySaving state, while others are in compensatingForEnergySaving state.

Peak-traffic situation and off-peak-traffic situation refer to the disposition of a network. For this use case, the following three different states are applicable to individual network elements: 1) notEnergySaving, 2) energySaving, and 3) compensatingForEnergySaving state.

These states are entered and left using the procedures energy saving activation, energy saving deactivation, energy saving compensation activation, and energy saving compensation deactivation.

It should be noted that the concrete actions for transferring a network element into an energySaving state (depicted as 'eSaving' in figure A.1) depend on the specific scenario and capabilities of the network element.

This use case can be implemented in the ES-below-Itf-N architecture and in the ES-above-Itf-N architecture. Depending on the architecture, energy saving decisions and corresponding state transfers are made by network elements (or element / domain managers) or by network management systems.

Annex B (informative): Use Case details: eNB overlaid use case

In order to assure the service connectivity and make no side effect on the service (there is a possible case that a UE may power on in the area of an eNB in ES), only the eNB overlaid by other eNBs (i.e. the area served by the eNB also covered by other eNBs) can enter into ES.

In this scenario, legacy systems, e.g. 2G/3G provide radio coverage together with E-UTRAN. Another case similar with this is that an area covered by different frequencies in E-UTRAN, i.e. inter-frequency case.

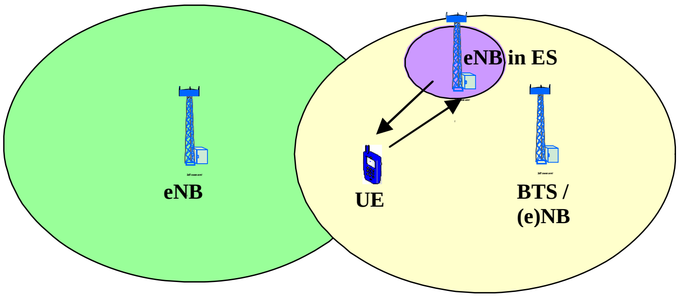

Figure B.1: ENB Overlaid Scenario

According to the definition of base station classes in [3] section 4.2, base stations can be categorized by Macro Cell (Wide Area Base Station), Micro Cell (Medium Range Base Station), Pico Cell (Local Area Base Station) and Femto Cell (characterized by Home Base Station). This category of base station can be applied to enhance the scenarios of inter-frequency eNB overlaid.

UC1: Inter-Frequency E-UTRAN eNB/Cell Coverage

In this scenario, two E-UTRAN cells (Cell A, Cell B) with separate frequency bands cover the same geographical area. Cell B has a smaller size (Pico Cell or Micro Cell) than Cell A (Macro Cell) and is covered totally by Cell A. Generally, Cell A is deployed to provide continuous coverage of the area, while Cell B increases the capacity of the special sub-areas, such as hot spots. The energy saving procedure in the coverage of Cell B (ES area) may be triggered in case that light traffic in Cell B is detected. Cell B deactivation of energy saving may also be triggered when the traffic of ES area (measured by Cell A) resumes to a high level.

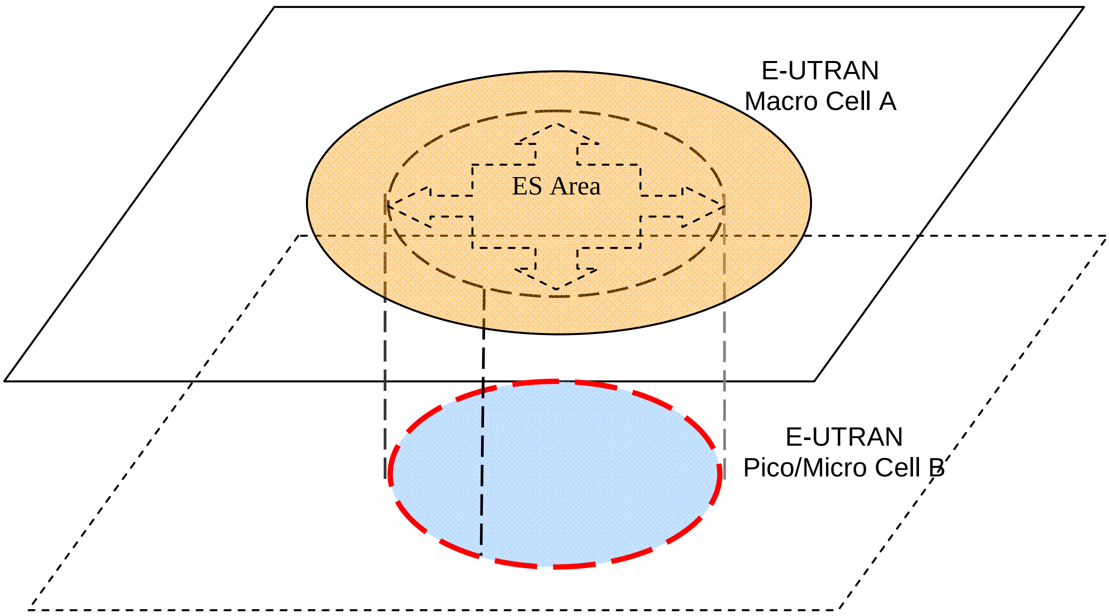

Figure B.2: Inter-Frequency E-UTRAN Cell Coverage

The inter-frequency E-UTRAN cell coverage use case also has a variation of hybrid deployment of Macro Cell and Femto Cell, which means different cell classes (Macro and Femto) cover the same geography area.

UC1a: Hybrid E-UTRAN Macro Cell and Femto Cell Coverage

In this scenario, two E-UTRAN cells (Cell A, Cell B) with different cell types cover the same geographical area. Cell B (Femto Cell) is covered totally by Cell A (Macro Cell). Generally, Cell A is deployed by eNB to provide continuous coverage of the area, while Cell B is deployed by Home eNB to increase the capacity of the special sub-areas, such as home or business mall or office. The energy saving procedure in the coverage of Cell B (ES area) may be triggered in case that light traffic or no traffic in Cell B is detected. Cell B deactivation of energy saving may also be triggered when the traffic of ES area resumes to a high level. Home eNB which deploys the femto cell can be totally switched off during the ES procedure.

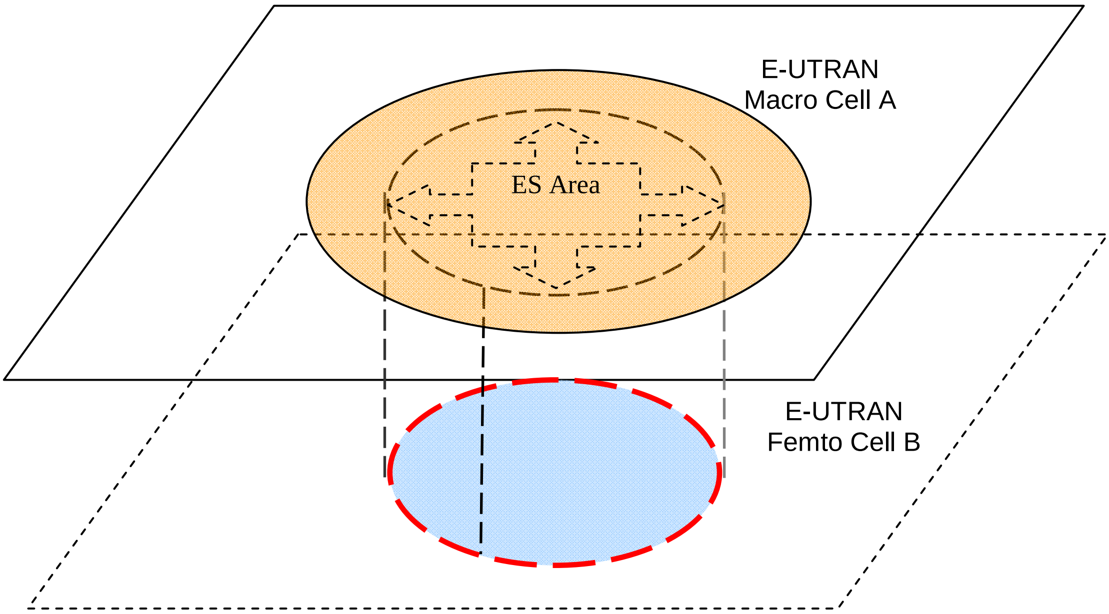

Figure B.3: Hybrid E-UTRAN Macro Cell and Femto Cell Coverage

UC2: Inter-RAT Cell Coverage

In this scenario, E-UTRAN Cell B is totally covered by inter-RAT Cell A (such as legacy system UMTS or GSM). Cell A is deployed to provide basic coverage of the voice or medium/low-speed data services in the area, while Cell B enhances the capability of the area to support high-speed data or multi-media services. The energy saving procedure in the coverage of Cell B (ES area) may be triggered in case that no high-speed data or multi-media traffic in Cell B is detected. Cell B deactivation of energy saving may be triggered when the high-speed data or multi-media service request in ES area is restarted again.

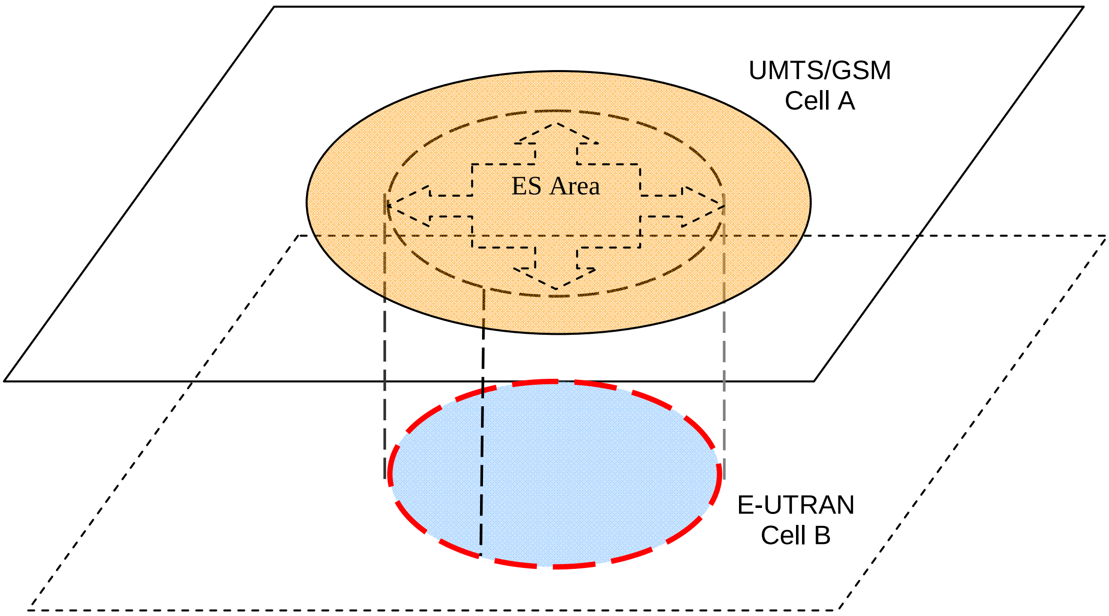

Figure B.4: Inter-RAT Cell Coverage

UC3: E-UTRAN Cell overlaid by multiple UTRAN/GERAN Cells

In this scenario, E-UTRAN cell X Cell is overlaid by multiple UTRAN/GERAN cells (cell A and cell B). The UEs that are served by E-UTRAN cell X may be located in the areas covered by cell A, cell B, or cell A/B. When cell X is triggered to enter the energy saving mode, cell A and cell B are required to provide the coverage for cell X. The trigger for cell X to exit the energy saving mode is based on the traffic loads or operation status of cell A and cell B. This use case applies if cell X is installed for capacity enhancement, but not to take care of UTRAN/GERAN coverage holes.

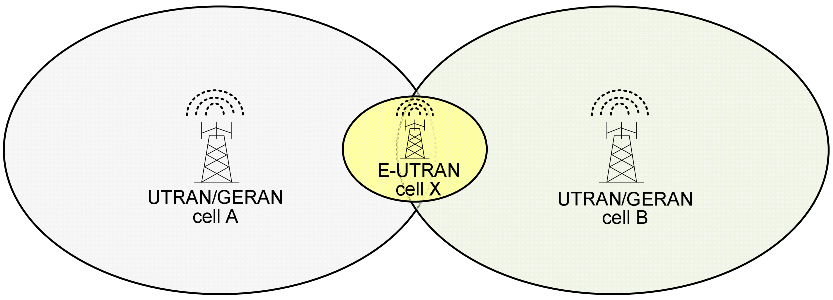

Figure B.5: E-UTRAN Cell overlaid by multiple UTRAN/GERAN Cells

Annex C (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2010-09	SP-49	SP-100513	--	--	Submitted to SA#49 for Information	---	1.0.0
2010-12	SP-50	SP-100768	--	--	Submitted to SA#50 for Approval	1.2.0	2.0.0
2011-01	--	--	--	--	Publication of SA approved version	2.0.0	10.0.0
2011-02	--	--	-	-	Editorial modifications	10.0.0	10.0.1
2011-03	SP-51	SP-110100	0001	1	Modify the energy saving compensation related use cases	10.0.1	10.1.0
2011-03	SP-51	SP-110100	0002	1	Add energy saving compensation deactivation requirement	10.0.1	10.1.0
2011-03	SP-51	SP-110100	0003	1	Modify the requirements about traffic threshold and time duration for Energy Saving Management (ESM)	10.0.1	10.1.0
2011-03	SP-51	SP-110100	0004	-	Modify errors in state name and in section title	10.0.1	10.1.0
2011-03	SP-51	SP-110100	0005	1	Clarify the description of energy saving compensation activation and deactivation over Itf-N	10.0.1	10.1.0
2011-03	SP-51	SP-110100	0006	-	Correct requirements for EM-centralized Energy Saving Architecture	10.0.1	10.1.0
Mar 2012	SP-55	SP-120056	0008	5	Relocate misplaced text for energy saving management concept	10.1.0	11.0.0
Mar 2012	SP-55	SP-120056	0009	2	Add Inter-RAT Energy Saving Management requirements from 32.834	10.1.0	11.0.0
Mar 2012	SP-55	SP-120056	0010	1	Add Inter-RAT Energy Saving Management concepts from TR 32.834	10.1.0	11.0.0
Mar 2012	SP-55	SP-120056	0011	1	Add Inter-RAT Energy Saving Management use cases	10.1.0	11.0.0
Jun-06	SP-56	SP-120371	0019	3	Clarify Inter-RAT Energy Saving Management requirement	11.0.0	11.1.0
Sep-2012	SP-57	SP-120573	0025	2	eNB overlaid use case	11.1.0	11.2.0
Sep-2012	SP-57	SP-120645	0026	2	Removal of Inter-RAT ES restriction for the time period during which energy saving is allowed	11.1.0	11.2.0
Dec-2012	SP-58	SP-120783	0027	1	IRP Manager switches off distributed ESM - Requirement and Use Case	11.2.0	11.3.0
		SP-120800	0028	-	Cleanup of energy saving management requirements		
		SP-129800	0029	-	Correction on references related to inter-RAT energy saving management		
		SP-120783	0030	3	Addition of information on probing to Energy Saving		
June 2013					Editorial correction (MCC): Annex A title was in style Normal	11.3.0	11.3.1
Sep-2014					Automatic upgrade (MCC)	11.3.1	12.0.0

History

Document history		
V12.0.0	October 2014	Publication